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Field of the Invention

The present invention relates to a projection system and, more particularly, to an illuminating system and method for improving asymmetric projection in a projection system.

Description of Related Art

FIG. 1 is a schematic diagram of a conventional first projection system 20. The projection system 20 is a single panel full color (RGB) system having a light source 21 with a parabolic concave reflector 211 to provide a white light beam. After reflected by the parabolic concave reflector 211, the white light beam passes through a converging lens 22 to converge the light beam 23 on a color wheel 24. The color wheel 24 comprises a series of a red color filter, a green color filter, and a blue color filter. When rotating around a shaft, the color wheel 24 has a series of red, green, and blue filters to intercept the light beam 23 in order. Therefore, the light beam 23 changes into a color light beam 25 as passing through the color wheel 24. Then, the color light beam 25 transmits in order through an integration rod 26, a condenser lens 27, and a stop 28. After the color light beam 25 passes through the stop 28, it transmits into a relay lens 29 and then impinges in a prism illuminator system 30. The prism illuminator system 30 can reflect the light beam from the light source 21, by using a mirror 31, to a light valve 10 constituted by a digital micro-mirror device or DMD. The prism illuminator system 30 can guides the reflected light having information content into a projection lens 32 for projecting an image onto a screen (not shown).

The DMD has an array of inclinable pixel mirrors. When any one of inclinable mirrors reflects a light beam to the screen, the inclinable mirrors is in an "on-state"; when reflecting a light beam to a position off the screen, the pixel mirror is in an "off-state"; when the pixel mirror is parallel to the DMD board, the pixel mirror is in a "flat-state", in other words, it is between the on-state and the off-state.

FIG. 2 shows a second projection system 40 in the conventional art. The difference between the first projection system 20 and the second projection system 40 is that the light source 41 in FIG. 2 has an elliptic concave reflector 411. The light source 41 can also provides a white light. The elliptic concave reflector 411 can reflect and converge a light beam, emitted from the light source 41, to a color wheel 44 without passing a converging lens. Except that, the second conventional projection system 40 in FIG. 2 is the same as the first conventional projection system 20 in FIG. 1. Actually, the second conventional projection system 40 is one embodiment of the first conventional

with a smaller F-number. Thus, that can avoid the overlap of light beams between on-state and flat-state to raise the contrast. Furthermore, by amplifying the light spot, the projection system will increase the total illumination efficiency of the optic system.

BRIEF DESCRIPTION OF DRAWINGS

[0013] FIG. 1 is a schematic view showing a first conventional projection system;

[0014] FIG. 2 is a schematic view showing a second conventional projection system;

[0015] FIG. 3 is a schematic cross-sectional view showing a rectangular-sectional light beam having no distortion in the first conventional projection system;

[0016] FIG. 4 is a schematic view showing a distorted rectangular-sectional light beam in the first conventional projection system;

[0017] FIGs. 5(A)-5(C) are schematic views showing an improving procedure by the use of an anamorphic surface unit in the present invention;

[0018] FIGs. 6(A)-6(B) are schematic views showing the axial-extended elliptic light spot on the stop;

[0019] FIGs. 7(A)-7(B) are spot diagrams respectively showing a brightness distribution of the light spots of the prior art and of the present invention on DMD;

[0020] FIGs. 8(A)-8(B) are spot diagrams respectively showing a brightness distribution of the screen of the prior art and of the present invention;

[0021] FIG. 9 is a schematic view showing the relative positions of the open-state, off-state, and flat state of the light beam passing through the stop of the projection lens in prior art;

[0022] FIG. 10 is an experimental data list showing the contrast between the present invention and the prior art.

DETAILED DESCRIPTION

[0023] Referring to the drawings, the present invention will be described in a

following embodiment. For solving the distortion of the prior art, the present invention provides an anamorphic surface unit for offsetting the distortion formed by two asymmetric diagonals of the light spot, so that the asymmetric light spot, resulting from inclined incidence of a projection system, can be improved into a more symmetric light spot.

[0024] In general, the anamorphic surface unit may be formed as one surface of a lens, reflector, or mirror. Concretely, the anamorphic surface unit may be formed on any surface of the light source 21, converging lens 22, condenser lens 27, relay lens 29, or mirror 31 of the projection system shown in FIG. 1.

[0025] The anamorphic surface unit is formed on one surface of the relay lens 29 in this embodiment, for example. Referring to FIGS. 5(A)-5(C), FIG. 5(B) shows a rectangular anamorphic lens having one normal surface and another convex surface with larger curvature at X-axis than Y-axis. FIG. 5(A) shows the distorted light spot on DMD, in which two diagonals at M and N direction is asymmetric each other, and the length of the N-direction diagonal is longer than that of the M-direction diagonal. If the relay lens 29 has the anamorphic surface shown as FIG. 5(B) and has the X-axis in the N-direction of the distorted light spot, and the Y-axis in the M-direction, the length of the N-direction diagonal can be shortened to improve the asymmetric light spot on DMD for achieving a more symmetric light spot, shown in FIG. 5(C), by means of the different amplifying rates due to the different curvature of the X-axis and the Y-axis. In the same principle, by the use of the anamorphic surface unit with the different curvature, the light spot can appropriately be symmetrized or produced a predetermined distortion.

[0026] FIGs. 6(A) and 6(B) respectively show that the light spot is displayed on the stop (not shown) of projection lens 32 when the relay lens 29 has an anamorphic surface unit and has no anamorphic surface unit. Because the relay lens 29 has the anamorphic surface with the different curvatures in X-axis and Y-axis to produce different amplifications, the light spot extends different lengths along the X-axis and Y-axis so as to form an elliptic spot. FIG. 6(B) shows that the Y-axis length of the light spot on the stop of projection lens 32 is elongated clearly, so that the shape of the light spot transforms a circular into an ellipse to increase the total light collection efficiency of projection system. The technology of the present invention will be described in detail as follows.

[0027] Referring to FIG. 7, FIG. 7(A) shows a DMD spot diagram of the prior art. FIG.

7(B) shows a DMD spot diagram of the present invention with an anamorphic surface unit. As FIG. 7(A), due to the inclined incidence, the light spot of the prior art generates a distortion and appears a diagonal extension from the down-left to up-right corner. That is, the length of the first diagonal L1 is longer than that of the second diagonal L2, shown in FIG. 4. On the contrary, by using an anamorphic surface unit to offset the distortion resulting from inclined incidence, a more symmetric light spot shown as FIG. 7(B) can be achieved. In contrast with the asymmetric light spot shown as FIG. 7(A), the extension on the diagonal of the DMD light spot, shown in FIG. 7(B), have been improved obviously.

[0028] Furthermore, because the light beam on DMD can only be reflected to the projection screen through the rear-end projection lens, an available rectangular region needs to be defined for matching the DMD within the light spot shown in FIGS. 7(A) and 7(B). Owing to the producing tolerance, the available rectangular region is defined most possibly within the DMD light spot and has the ratio of length to width for corresponding to the rectangular projection screen.

[0029] FIG. 8(A) and FIG. 8(B) respectively show the screen brightness distribution diagrams of the prior art shown as FIG. 7(A) and the present invention when the light beam on the DMD is reflected onto the screen through the rear-end projection lens. Because of the asymmetric DMD light spot generated from the conventional projection system, a boundary range of the available rectangular region shown as FIG. 7(A) is lost larger than that of the available rectangular region shown as FIG. 7(B). It results in that the total brightness of the rectangular region in the prior art is lower than that in the present invention. As a result, the deep color, shown in FIG. 8(B), representing the high brightness distribution region of the present invention is larger than that of the prior art in the brightness region and uniformity of the screen diagram, as shown in FIG. 8(A). Furthermore, as shown in FIG. 8 (B), the X-axis (transverse axis) and Y-axis (vertical axis) brightness distribution of the present invention is also indeed more uniform than that of the prior art in the screen diagram.

[0030] FIG. 9 shows the relative positions of the on-state, off-state, and flat state of the light beam at the stop of the projection lens 32. The solid line respectively represents the on-state light beam 61, flat state light beam 62, and off-state light beam 63 of the prior art, and the dotted line respectively represents the on-state light beam 64, flat-state light beam 65, and off-state light beam 66 of the present invention. In theory, the bigger the on-state light beam 61 is, the more light flex can be allowed to enter into the stop for achieving better brightness. If the on-state light beam 61 is

enlarged to produce a light spot 611 having the same size as the stop 67, the flat-state light beam 62 and off-state light beam 63 will also be enlarged as light spot 68 and 69 respectively. That causes some overlaps between light spot 611 and light spot 68 to decrease the projection contrast. Therefore, the on-state light beam 61, flat state light beam 62, and off-state light beam 63 of the prior art are set to be next to each other and have no X-axial overlap between them, so that the maximum light flux can be allowed to pass without the sacrifice of contrast to achieve the best balance.

[0031] Above-mentioned on-state light beam 61, flat-state light beam 62 and off-state light beam 63 of the prior art are respectively improved to form the on-state light beam 64, flat-state light beam 65 and off-state light beam 66 of the present invention. That can achieve the maximum light flux and avoid the overlaps between the on-state light beam 64, the flat-state light beam 65 and the off-state light beam 66. The present invention uses an anamorphic surface unit for producing two asymmetric orthogonal axes to offset the distorted light spot formed by the inclined incidence of the prior art, so as to achieve a more symmetric light spot. Meanwhile, the present invention may also use the feature of two asymmetric orthogonal axes to extend the light spot of the on-state light beam 64, flat-state light beam 65, and off-state light beam 66 along Y-axis. Then, the stop of the present invention is enlarged (i.e. the F number decreases). Thus, the present invention can make sure that the elliptic light beam with the larger light flux passes without any loss, and avoid the overlaps between the on-state light beam 64, flat -state light beam 65, and off-state light beam 66.

[0032] Referring to FIG. 10, the experimental data list shows the contrast between the present invention and the prior art. The experimental datum includes the percentages of DMD efficiency, overfill, the projection output efficiency of on-state, and the projection output efficiency of flat-state. The right columns of the list show the improving rate of the present invention compared with that of the prior art. As to the improving rates of the present invention, the DMD efficiency is 4.6%; the overfill loss is 16.8%; the projection output efficiency of on-state is 2.9%; the projection output efficiency of flat-state is 69.2%.

[0033] Although the reflective DMD is a example for describing the above preferred embodiments, it can be replaced with a Liquid Crystal On Silicon (LCOS) or a Liquid Crystal Display (LCD) panel.

[0034] The invention has been described using exemplary preferred embodiments. However, it is to be understood that the scope of the invention is not limited to the

projection system 20. To simplify the description, the first conventional projection system 20 is described as an example in the following specification, but all of the concepts can be fully suitable for the second conventional projection system 40 in FIG. 2.

In the first projection system 20, from the light source 21 providing white light to any optical element the light beam passes through before the light valve 10, the optical elements such as the converging lens 22, the color wheel 24, the integration rod 26, the condenser lens 27, the stop 28, and the relay lens 29, have the geometrically symmetric feature. Therefore, as shown in FIG. 3, before obliquely impinging onto the light valve 10, the light beam has a rectangular cross section to form a rectangular-sectional light beam 51 with a feature of an intensely uniform illumination. If any above-mentioned optical elements and their assembly are perfect, the length of a first diagonal line L1 will be equal to that of a second diagonal line L2 in FIG. 1, i.e. the rectangular-sectional light beam 51 has no distortion.

When the rectangular-sectional light beam 51 having no distortion as shown in FIG. 3 passes through the prism illuminator system 30 and impinges onto the DMD light valve 10, a light spot 52 formed on the DMD light valve 10 is distorted since the rectangular-sectional light beam 51 obliquely impinges onto the light valve 10. In the rectangular-sectional light beam 51, the length of the first diagonal line L1 is not equal to that of the second diagonal line L2, i.e. L1>L2.

The distortion in the above-mentioned prior art has at least two drawbacks as follows: the reduction on the uniform brightness of the light spot; the brightness loss on circumference of the light spot from the extension of the first diagonal L1, resulting in decreasing the light collecting efficiency.

SUMMARY OF INVENTION

[0011] One objective of the present invention is to provide a method for offsetting two asymmetric diagonals of the distorted light spot. By the use of an anamorphic surface unit of a projection system, the method will improves the asymmetric light spot resulted from the inclined incidence to achieve a more symmetric light spot.

[0012] The other objective of the present invention is to use an anamorphic surface unit for producing two asymmetric orthogonal axes which are perpendicular to each other so that an illuminating system can generate a parabolic-sectional light beam

disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements. The scope of the claims, therefore, should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

WHAT IS CLAIMED IS:

1. An illuminating system for improving asymmetric projection comprising:

a light source;

a projection lens which projects an image from the light source onto a screen;

a light path extending from the light source to the projection lens;

a light valve disposed in the light path, which reflects an incident light beam through the light path to the projection lens or to a predetermined direction for deviating from the projection lens; and

an anamorphic surface unit placed in the light path between the light source and the light valve.

2. The illuminating system for improving asymmetric projection of claim 1, further comprising a mirror disposed between the light valve and the anamorphic surface unit.

3. The illuminating system for improving asymmetric projection of claim 1, wherein the light valve is a Liquid Crystal On Silicon (LCOS).

4. The illuminating system for improving asymmetric projection of claim 1, wherein the light valve is a Digital Micro-mirror Device (DMD).

5. The illuminating system for improving asymmetric projection of claim 1, wherein the light valve is a transmitting Liquid Crystal Display (LCD) panel.

6. The illuminating system for improving asymmetric projection of claim 1, wherein the anamorphic surface unit is an anamorphic lens.

7. The illuminating system for improving asymmetric projection of claim 1, wherein the anamorphic surface unit is a condenser lens.

8. The illuminating system for improving asymmetric projection of claim 1, wherein the anamorphic surface unit can be a reflecting surface of the light source, or any one surface of converging lens, condenser lens, relay lens, and mirror.

9. A method for improving an illuminating system of asymmetric projection, wherein the illuminating system of asymmetric projection comprises a light source and a light valve, wherein the light source produces a light beam to obliquely impinging onto the light valve, so as to generate a light spot with two asymmetric diagonals thereon, the method comprising:

disposing an anamorphic surface in the light path for offsetting two asymmetric diagonals of the light spot into a more normal rectangle.

10. The method for improving the illuminating system of asymmetric projection of claim 9, wherein the anamorphic surface unit is an anamorphic lens.

11. The method for improving the illuminating system of asymmetric projection of claim 9, wherein the anamorphic surface unit is an anamorphic reflecting surface.

12. The method for improving the illuminating system of asymmetric projection of claim 9, wherein the anamorphic surface unit elongates the Y-axial length of the light spot in on-state, flat-state, and off-state in order to form non-overlapping elliptic light beam.

ABSTRACT OF THE DISCLOSURE

An illuminating system and method for improving asymmetric projection includes a light source, a projection lens for projecting an image onto a screen, a light path extending from the light source to the projection lens, a light valve disposig in the light path, an anamorphic surface unit disposing between the light source and the light valve in the light path. The anamorphic surface unit offsets a distortion of a light spot resulted from obliquely incidence on the light valve, thus an asymmetric light spot can be improved as a more symmetric one to increase illuminating collection efficiency and uniformity. The anamorphic surface unit is also used for producing two asymmetric orthogonal axes so that an illuminating system can generate a parabolic-sectional light beam with a smaller F-number. Thus, that can avoid the overlap of light beams between on-state and flat-state to raise the contrast. Furthermore, by amplifying the light spot, the projection system will increase the total illumination efficiency of the optic system.